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and Supplement (1963)

to

National Aeronautics and Space Administration

from

Department of Physics

Florida State University

Radio Astronomy Programme

Period: February 1 through July 31, 1964

Submitted by

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Principal Investigator

ABSTRACT

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Jupiter has not been well placed for radio observation during the period of the present report. Analysis of data taken in 1963 has continued and a first report of the 18 mc/s spaced-sit observations has been completed. Correlation coefficients between Jupiter activity and various indicators of solar activity have been computed but these do not indicate any statistically significant cross correlation during 1963. A detailed study is now in progress to examine the possibility of a more complex relationship between the phenomena.

During the 1964 apparition Jupiter will be monitored simultaneously at 18 mc/s from five well separated points along a north-south line on the Earth's surface in an attempt to determine the extent to which the radiation might be affected by the Earth's ionosphere.

Polarization observations and spaced-site observations have commenced for the 1964 apparition although the Radio Observatory has suffered two set-backs from damage in recent storms.

Data is to be supplied to the NASA Space Science Data Center, Greenbelt, Maryland as from 1961 onwards.

## 1. Introduction

Jupiter has not been well placed for radio observation during the period of the present report. The time has been used mostly for continuing the analysis of data taken in 1963, for establishing new overseas stations for an extension of the spaced-site observations and for equipment servicing and modification in preparation for the 1964 apparition of Jupiter. Storm damage, on two separate occasions, has necessitated a considerable amount of repair work.

## 2. Equipment

The following equipment is in operation at the time of writing:

a. Tallahassee

Crossed five-element Yagi polarimeters at frequencies of 16, 18, 22, and 26 mc/s. Left and right hand components are compared using electronic switching circuits.

Square corner reflector at 18 mc/s as a standard for comparison with an identical system at the Florida State University Station at St. Osyth, England.

b. St. Osyth, England

Square corner reflectors at 18, 22 and 27 mc/s.

Two 18 mc/s four element Yagis, azimuthally mounted on 35 ft. towers (standard units for overseas stations described in Section 2 c) separated by ten wavelengths. This system can be used as a phase-switched interferometer or each aerial can be used as an independent radiometer for studying burst structure with a double channel high-speed recorder.

c. Ibadan, Valencia, Trondheim

One standard 18 mc/s unit at each station. This consists of a four element Yagi antenna azimuthally mounted on a 35 ft. tower. The antenna can be directed in azimuth by means of a motor with a selsyn operated indicator system and in altitude by a manually operated crank-over. A Hallicrafters communications receiver is used to amplify the signals from Jupiter which are recorded on an Elliott pen-recording milliammeter. A standard noise generator is available for calibration at each site.

d. Grahamstown, South Africa (Independent collaborators)

18 mc/s eight-dipole broadside array and a single folded dipole 100 miles apart. Identification is partly based upon a comparison of records from both sites (see enclosed preprint).

## 3. Observations

The 1964 observations began on July 15. Jupiter is not ideally placed for the first few weeks but, as in previous years, this period is used for training new assistants in the nightly observatory routine. A team of seven observers, including the Principal Investigator, share the night work at the Observatory. Small groups operate the overseas stations. The general routine and procedure is similar to that used in previous years and has been described in detail in a recent paper by Barrow (1).

## 4. Polarization

The 1963 observations have been analyzed and were published recently (1). Further observations are in progress at the time of writing. As mentioned in the previous report, it appears that the two lower frequencies, 16 and 18 mc/s., are of the greatest interest. It would be very desirable

to attempt the measurement of the degree of polarization. There are several ways in which this could be done, for example, by measuring the amplitude of the cross-correlation function between the right and left-hand intensities or by measuring additional component intensities with a differently polarized antenna. These and a number of other methods have been discussed by Cohen (2). Dispersion by Faraday rotation in the Earth's ionosphere makes this a rather uncertain measurement at low radio astronomy frequencies but calculations given by Cohen suggest that the results might be useful as low as 18 mc/s if a sufficiently narrow receiver bandwidth is available. This experiment may have to await additional funding, however.

## 5. Spaced-site Experiments

a. A first analysis has been made of the data obtained at 18 mc/s in 1963 from the three participating stations in Tallahassee, England, and South Africa. An account entitled "Preliminary Results of Spaced-site Observations of Jupiter in 1963" [Barrow et al. (3)] is enclosed with this report. Following Roberts (4), correlation coefficients between Jupiter activity and various indicators of solar activity have been computed but these do not indicate any statistically significant cross correlation.

All of the claims that have been made so far of so-called correlations between Jupiter activity and solar activity are based essentially upon the observation that many Jupiter storms occur within a few days after a period of solar activity. Estimates of an average delay time between the phenomena (usually based upon a single series of observations from one site only) range from two to ten days. Assuming that the two phenomena are related at all, this suggests that either a longer daily observation period of Jupiter is necessary to show the relationship or else the relation is too complex to

be revealed by such simple analysis. As the 1963 experiment allowed Jupiter to be monitored continuously for about sixteen hours daily, it appears, so far, that the second possibility may be the more significant. A detailed study of the data is now being made to examine this second possibility further.

b. Evidence continues to appear of terrestrial ionospheric modification of the radiation [see page 5 of the attached preprint and also a recent paper by Warwick and Dulk (4)] and it appears that the new spaced-site experiment is very timely. Standard 18 mc/s units have been installed along an approximate north-south line through St. Osyth so that Jupiter can be monitored simultaneously from four different well-separated points on the Earth's surface.* It is hoped that a comparison of the records taken at each site as well as a comparison of the overall occurrence probabilities observed will help to indicate the extent of the effects involved. A line through St. Osyth was chosen because of the striking differences, observed in 1963, between the amount of activity recorded in England and in South Africa.

The new sites have been established during the summer of 1964 by the Principal Investigator and by Mr. Hyde. At each location a University Faculty supervisor has been appointed and a group of undergraduate assistants have been selected and trained for monitoring the equipment at night. The station in Norway has been arranged at Trondheim and not at Bergen as originally planned because of the non-availability of a suitable Faculty supervisor at the latter university. Data is to be sent to Florida State University for analysis. The new stations have been established at the following locations:

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*Five points if Rhodes University is included. This group is financed by the South African government, however, and they do not have the same receiving equipment that has been described as standard for the other stations although the performance and sensitivity is similar. Collaboration proved to be valuable during 1963 and is to be continued in the future.

Department of Physics, University of Ibadan, Nigeria

Meteorological Observatory, University of Valencia, Spain

Department of Electrical Engineering, Technical University of Trondheim, Norway

## 6. Storm Damage

The Observatory has suffered two serious set-backs in recent storm damage. On one occasion a section of the 18 mc/s corner reflector was badly damaged by high winds. On another occasion the site was struck by lightning and considerable damage resulted to receivers, the switching circuitry, and an antenna steering mechanisms. This is being repaired as quickly as possible and a claim has been made on insurance. The material damage amounted to over $1200 but the loss in time has been considerably more serious.

## 7. Visitors

Mr. Isaacson of the Goddard Space Flight Center visited the Radio Observatory recently and, as a result of the subsequent discussions, arrangements are being made for data to be supplied to the NASA Space Science Data Center, Greenbelt, as from 1961.

Other recent visitors to the Florida State University Radio Observatory include Professor Sir Bernard Lovell, Nuffield Radio Observatory, University of Manchester, England; Dr. Roger Gallet, NBS, Boulder, Colorado; and Dr. Raymond Hide, MIT, Cambridge, Massachusetts.

## 8. Plans for the Future

Plans are being made for moving the Radio Observatory to a new site early in 1965. The Radio Astronomy Programme has grown considerably since

its commencement in 1960 and a larger piece of land is required if the study of polarization is to continue with larger separated antennas as suggested in the previous report. The present site is also required by the University for future expansion. A new location to the south of Tallahassee is being considered. This is much larger and should also be less liable to local interference. The University will undertake the removal of the present equipment and the provision of a new building. It is hoped to have the removal completed in time for new antennas to be constructed and operating for the 1965-6 apparition. This should be a particularly favorable apparition as Jupiter will be in a very northerly declination and, consequently, observable close to the zenith at meridian transit. A proposal for continued support is in preparation and will be submitted to NASA in the near future.

REFERENCES

1. Barrow, C. H., Icarus, 3, 66 (1964).

2. Cohen, M. H., Proc. I.R.E., 46, 172 (1958).

3. Barrow, C. H., Hyde, F. W., Gruber, G. M., Bosch, M. C., Resch, G. M., submitted to Nature, 1964.

4. Warwick, J. W. and Dulk, G. A., Science, 145, 380 (1964).

Publications: February 1 through July 31, 1964

"Polarization Observations of Jupiter at Decameter-Wavelengths", Barrow, C. H., Icarus, 3, 66 (1964).

"Decameter-Wave Observations of Jupiter in 1963", (Abstract) Barrow, C. H., Bull. Am. Phys. Soc., Series II 9, 352 (1964).

"Recent Radio Observations of Jupiter", Barrow, C. H., J. Brit. Ast. Assn., (In press).

"Preliminary Results of Spaced-site Observations of Jupiter in 1963", Barrow, C. H., Hyde, F. W., Gruber, G. M., Bosch, M. C., and Resch, G. M. Submitted to Nature, 1964.

"Spaced-site Observations of Jupiter", Hyde, F. W., J. Brit. Ast. Assn., (In press).

1964 Astronomical Year Book, (Eyre and Spottiswoode, London, 1964) Chapter entitled "The Radio Sun" Hyde, F. W.

Talks given during the Period:

C. H. Barrow

"Recent Radio Observations of Jupiter at Florida State University"
Florida Academy of Sciences Meeting, Winter Park, Florida
March 20, 1964.

"Recent Radio Observations of Jupiter"
British Astronomical Association Meeting, London
May 27, 1964.

Colloquia

Department of Physics, University of Ibadan, Nigeria
April 29, 1964.

Departments of Physics and Electrical Engineering
Technical University of Trondheim, Norway
June 29, 1964

F. W. Hyde

"Spaced-site Observations of Jupiter"
British Astronomical Association Meeting, London
May 27, 1964.

G. M. Resch

"Spaced-site Experiments Operated by Florida State University Radio Observatory"
Florida Academy of Sciences Meeting, Winter Park, Florida
March 20, 1964.

G. M. Gruber

"Spaced-site Observations of Jupiter"
Conference of the South African Institute of Physics
June, 1964.

The Principal Investigator and Mr. F. W. Hyde visited the Harestua Radio Observatory of the University of Oslo, Norway, during journey from England to the outstation at Trondheim. The Principal Investigator visited the Nuffield Radio Observatory, Jodrell Bank, England, to confer with Professor F. Graham Smith, consultant for the spaced-site experiments.

Personnel Working on the Grant:

(a) Tallahassee

C. H. Barrow, Assistant Professor and Principal Investigator

D. Morrow, Graduate Assistant

G. M. Resch, Graduate Assistant

J. H. Cocke, Electronics Technician

G. R. Adcock, Undergraduate Assistant

K. Peale, Undergraduate Assistant

*N. E. Thagard, Undergraduate Assistant

*H. Rolleston, Undergraduate Assistant

*C. Kline, Undergraduate Assistant

* Terminated during the period.

(b) St. Osyth

F. W. Hyde, Director of St. Osyth station (Self supported).

D. Crosswell, Part-time Secretary

R. Hawkins, Undergraduate Assistant

R. Womble, Undergraduate Assistant

P. Morris, Undergraduate Assistant

G. Coleman, Undergraduate Assistant

Personnel Associated with the Project.

(a) Grahamstown, South Africa

E. E. Baart, Lecturer in Physics and Director of Radio Astronomy

M. C. Bosch, Graduate Assistant

G. M. Gruber, Graduate Assistant

(b) Local supervisors for the 1964 spaced-site observations.

R. W. Morriss, Lecturer in Physics, University of Ibadan

J. Catala, Professor of Physics, University of Valencia

H. Torgerson, Engineer, Technical University of Trondheim